

Electroluminescent three-dimensional photonic crystals based on opal-Zn₂SiO₄:Mn and opal-GaN-ZnS:Mn composites

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Electroluminescent three-dimensional photonic crystal (PC) structures based on opal-Zn₂SiO₄:Mn and opal-GaN-ZnS:Mn composites have been fabricated for the first time. The opal-phosphor composites were synthesized by chemical bath deposition technique. The crystal structure of the composites synthesized was investigated by the powder X-ray diffraction method. Electroluminescent structures were made from synthesized composites by depositing a conductive semitransparent indium-tin oxide (ITO) layer on one PC facet and a layer of BaTiO₃ powder dispersed in an organic compound on another, followed by deposition of a silver paste layer. Electroluminescence (EL) was excited by an alternating current electric field, whose characteristics were well below the breakdown threshold (strength ~10⁴-10⁵ V/cm, frequency ~0.1-2 kHz). The composites synthesized have been found to demonstrate an effective EL comparable with commercially produced phosphors both in green (opal-Zn₂SiO₄:Mn) and yellow (opal-GaN-ZnS:Mn) spectral ranges.

The photonic bandgap properties of the opal-phosphor composites have been studied by measuring angular resolved Bragg reflection spectra from the (111) surface of the PCs. The registration of the reflection spectrum was followed by recording the EL spectrum from the same place of the sample. Both spectra were measured through the ITO film from the surface regions of 2×2 mm in size. The EL spectrum was founded to be considerably modified by the photonic band gap (PBG) to become anisotropic in accordance with the PBG angular dispersion.

The results demonstrated show the opportunity to control flow of light in conventional light-emitting devices and open the way to create PBG-governed optoelectronic structures.

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